IGARSS'00
Special Session: Spaceborne SAR Missions

Making A Case for Daily SAR Observations of the Ocean Surface: A New Ocean SAR Mapper System

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The fine resolution of synthetic aperture radar (SAR) yields exciting views of the two-dimensional ocean surface and its interactions with the atmosphere, long waves, and currents. However, the high data rates and power required to achieve this fine resolution limit the available swath widths and hence the temporal and spatial sampling of the ocean surface, in turn limiting SAR ocean observations to periodic "snapshots" rather than synoptic, frequent views. The wide swath capability of RADARSAT, Envisat's ASAR, and Alos's PALSAR enhance ocean sampling down to a few days. However, the dynamics of many important ocean and atmospheric processes have shorter time scales and may require an entirely new satellite concept to adequately capture these dynamics. We have developed two different satellite unique SAR mission concepts with the goal of achieving daily ocean observations. The first concept is for a mission with increased swath width (800 km) using a single antenna flown at a higher than normal altitude (around 1370 km), and the second considers using a spacecraft carrying two antennas to achieve two 500-km swath widths in a more conventional orbit.

In this paper, we will summarize the mission concepts, providing scientific and operational requirements, preliminary SAR designs and mission orbital concepts. Trade-offs between the two missions are discussed. Then we will continue development of these mission concepts through further examination of instrument requirements based on recent scientific and operational results particularly in deriving wind speed and direction from RADARSAT imagery and in more detailed orbital repeat coverage analysis.

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Outline

Overview of science and operational requirements

Review of ocean mapper concept
Ref: Holt and Hilland, JH-APL Tech. Digest, 2000

Additional coverage maps with various scenarios (1 or 2 satellites, 1 or 2 antennas)

Motivation for Study

Match time scales of key ocean processes with SAR imaging (not well done with any past, present, or future SAR)

>Improve temporal and spatial sampling of mesoscale air-sea conditions & ocean circulation

>Match-up better with other ocean sensors (SST, ocean color, scatterometers, etc)

>Enable monitoring rather than case studies, will expand increase applications & user community)

>Help to overcome vagaries of Mother Nature that reduce feature detection in SAR (usually high winds)

Inherent Difficulties - SAR Viewing Ocean

1. SAR's high power requirements — >Lower frequencies more manageable

2. Reduced ocean sensitivity at lower frequencies — >Higher frequencies better for ocean

   Note conflict between 1 and 2

3. Narrow range of viable ocean incidence angles — >Increasing swath width by itself is not solution

4. Trade-off between resolution and swath width

Basic Ocean Requirements for this Study

Science:	**Mesoscale Circulation Features** **-currents, fronts, eddies, internal waves**	
	Mesoscale Air-Sea Interactions **-wind fields, atmospheric boundary layer processes**	
Operations:	**Ship detection (fishing, traffic)** **Pollution detection (oil slicks)** **Iceberg detection - seasonal**	
Configuration:	**Frequency**	**C-band (5.3 GHz)**
	Polarization	**VV**
	Resolution-m/Looks	**Science - 150 /10 or more** **Operations - 50/4 or more**
	Incidence angles	**Science - 19-45 deg** **Operations - 19-58 deg**
	Noise equivalent sigma0	**> -20 dB**
	Repeat Interval	**Global access within < 3 days consistent viewing geometry,** **Sun-synchronous**

Selected Study Options

One Antenna

Q - What is the widest swath you can get and how can it be achieved?

Go to higher orbital altitudes to increase swath width while maintaining constrained range of viewing angles

Two Antennas on Single Platform

Q - Is there a mission design that provides good coverage and rapid repeat using 2 antennas?

Similar coverage as one antenna above but maintain constrained range of viewing angles with known performance (a la Radarsat, Envisat)

Table 1. One Antenna

	Radarsat1	Ocean Mapper
Frequency/Polarization	C - HH	C - VV
Altitude km	800	1368
Swath Width / Beams	520 / 4	800 / 8
Resolution / Looks		
Science	100 m x 100 m / 8	150m x 150m / 28
Operations		50 x 50 /12
Antenna Dimension m	15 x 1.5	16.5 x 1
Incidence Angle (deg)	20 - 49	24-52
Data Rate MB/s	105	360-97
Bandwidth Mhz	11, 17	20
Noise Equiv Sigma 0 - dB	-20	< -21
Azimuth Ambiquity - dB	-22	< -15 (boresight)
Range Ambiquity - dB	-18	< -21
Peak Transmit Power - kW	5.5	6
Average DC power - W	280	572

Table 2. Two Antennas

	Radarsat1	Ocean Mapper
Frequency/Polarization	C - HH	C - VV
Altitude km	800	819
Swath Width / Beams	500 / 4	2 x 500 / 5
Resolution / Looks		
Science	100 m x 100 m / 8	150m x 150m / 60
Operations		50 x 50 / 4
Antenna Dimension m	15 x 1.5	16 x 0.5
Incidence Angle (deg)	20 - 49	21-48
Data Rate MB/s	105	56-102
Bandwidth Mhz	11, 17	20
Noise Equiv Sigma 0 - dB	-20	<-18 boresight
Azimuth Ambiquity - dB	-22	< -16
Range Ambiquity - dB	-18	< -18
Peak Transmit Power - kW	5.5	3.6
Average DC Power - W	280	455

Summary

Developed two viable mission designs, both of which improve SAR sampling

<u>One Antenna - Low Earth Orbit</u>

•800 km swath, 3-day repeat orbit to obtain >85% coverage at equator, complete coverage at 30 deg latitude with one look direction.

Note: Two spacecraft in 2-day repeat, offset by one day, would provide complete coverage every two days

•Reasonable power and technology already in practice

•Difficulties - higher altitude requires radiation hardening, 8 sub-swaths difficult for calibration and processing

Two Antennas

• 2 x 500 km swath, 5-day orbit provides complete coverage at equator, 3 sets of sliding 2-day near repeats and 2 sets of 3-day near repeats at 30 deg latitude

•Second platform > 3-day repeat with offset

•Mirrors currently operating SAR systems.

•Difficulties - packaging 2 antennas into launch vehicle (use inflatable antennas - needs studies on survivability)